[0198] Again, the larger enhancement factor at lower temperature is observed indicating that the groove features effectively speed up the otherwise slow reaction rates.

TABLE 2

	T		
	Methane conversion		E_factor
C.	baseline	Case B (45 deg angle)	Case B (45 deg angle)
850	24.2%	27.2%	12.4%
700	5.4%	7.6%	41.8%

[0199] In the Table below we see that the initial reactor performance for this geometry can be ranked for the angles tested from best to worst as: 60 degrees>45 degrees>30 degrees.

TABLE

	Impact of the angle		
	T E_factor		
C.	30 degree	45 degree	60 degree
700	27.8%	41.8%	59.7%

C) Surface Grooves at an Oblique Angle with the Flow Direction—on both Opposite Walls of the Channel—Symmetry—Diverging Flows within the Grooves

[0200] Simulations were also run with the v-shape grooves pointing in the opposite direction—that is against the flow direction or in the cis-B orientation, and, surprisingly, the same enhancement factor was measured as the case with the v-shape grooves pointing with the flow direction. The flow patterns were quite different for the grooves of opposite orientations. For the v-shape features pointed toward the direction of flow, the flow inside thet grooves rolled toward the center of the channel or point of the v. For the v-shape features pointed against the direction of flow, the flow rolled toward the sides of the channel. Inside a given groove the pressure is at the highest level at the point of V. For both cases, the total increase in surface area or available surface sites for reaction remains constant thus suggesting equal performance. The narrow microchannel gap (0.0125") gave little external mass transport resistance for the flat channel and thus transverse and perpendicular flow effects had little effect. It is expected that transverse and perpendicular flow effects will be more significant as the reaction channel gap increases.

TABLE 4

	T		
	Methane conversion		E_factor
C.	baseline	Case C (−45 degree)	Case C (−45 angle)
850	24.2%	27.1%	12.3%
700	5.4%	7.6%	41.8%

Again, the concentration distribution is symmetric referring to the middle plane, except an un-even distribution of methane in the transverse direction is observed (opposite to that observed in case B) where the methane concentration is locally high at the center of the channel width. This could lead to an un-even reaction rate distribution which in turn could cause an un-even heat load. However, this un-even heat load should be relieved effectively considering the heat conduction along the transverse direction within the channel walls.

D) Surface Grooves at an Oblique Angle with the Flow Direction—on both Opposite Walls of the Channel but with Different Orientation

In examples B and C, mirror image surface features in terms of shape and orientation were present on opposite walls of the channel. In this example, grooves of type B are imposed on one wall, and grooves of type C are imposed on the opposite wall (opposing angles). This orientation is also referred to as a trans configuration. The plane of symmetry at the middle of the channel is lost.

[0201] The dominant flows within the surface features on the opposite walls point to opposite directions transverse-wise. On one side, the flow turns from the edge close to the center of the main flow channel to the farther edge. While on the opposite side, the flow turns from the edge farther away from the center of the main flow channel to the edge close to the center of the flow channel. These flow patterns within the surface grooves lead to no dominant transverse flow direction in the main flow channel. This is quite distinct from the presence of dominant flow directions in case B (the flow points to the side from the center) and C (the flow points to the center from the sides of the flow channel).

[0202] Again, un-even distribution of methane in the transverse direction is observed but at a lesser degee of non-uniformity. Different from the case B and C, the methane concentration distribution along the transverse direction is not monotonic. On one side, the concentration at the center is higher than that near the side wall of the channel. On the other side, the concentration near the side walls of the channel is higher than that near the center of the flow channel. The grooves of opposite orientations at opposite walls act to average the concentration distribution and flow field. The surface features layout with non-perfect symmetry, imperfect symmetry, or asymetric features on the opposite walls offer better initial reactor performance compared to the symmetric layout as shown in case B and C.

TABLE 5

	T		
	Methane conversion		E_factor
C.	baseline	Case G (asymmetric)	Case G (asymmetric)
700	5.4%	7.9%	46.3%

These results show nearly equal performance to the case with equal surface features on both sides of the wall. There is a slight additional enhancement from having both features coordinated in a push-pull manner to improve the perpendicular flow—thus a slight reduction in the external mass